



# DNV GL

## EXPERIENCE MATTERS

Development and Engineering Services – Renewable Energy

## Overview

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1. Company overview
2. Overview of the Development and Engineering Services Team
3. Value Proposition
4. Detailed Service Descriptions
5. Managing Technical Risks

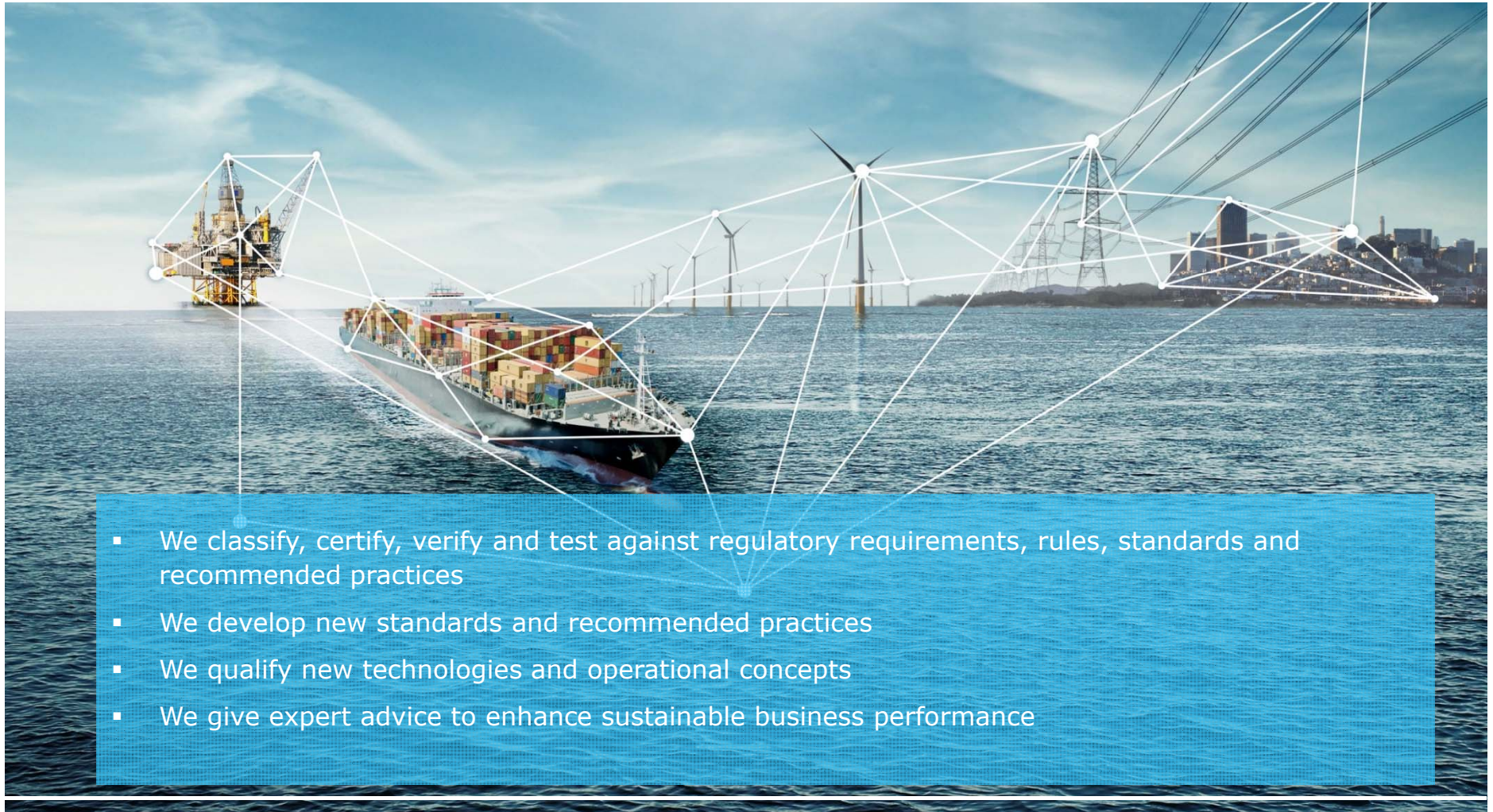
# 1. Company Overview

## In a challenging world we make businesses better prepared





## Only by connecting the details can we impact the bigger picture



- We classify, certify, verify and test against regulatory requirements, rules, standards and recommended practices
- We develop new standards and recommended practices
- We qualify new technologies and operational concepts
- We give expert advice to enhance sustainable business performance



## We call it the broader view



## Industry consolidation

DNV·GL



NOBLE DENTON



GARRAD  
HASSAN



ADVANTICA

## Global reach – local competence

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**150**

years

**400**

offices

**100**

countries

**16,000**

employees



## Committed to innovation

**5%** of annual revenue reinvested  
into research and  
development every year

**70** internal technology  
projects annually

**170** industry standards and  
recommended practices

**100** joint industry projects  
each year



# ENERGY





# Transition to a safer, smarter and greener energy future



Increasing global demand for energy

Integration of energy markets

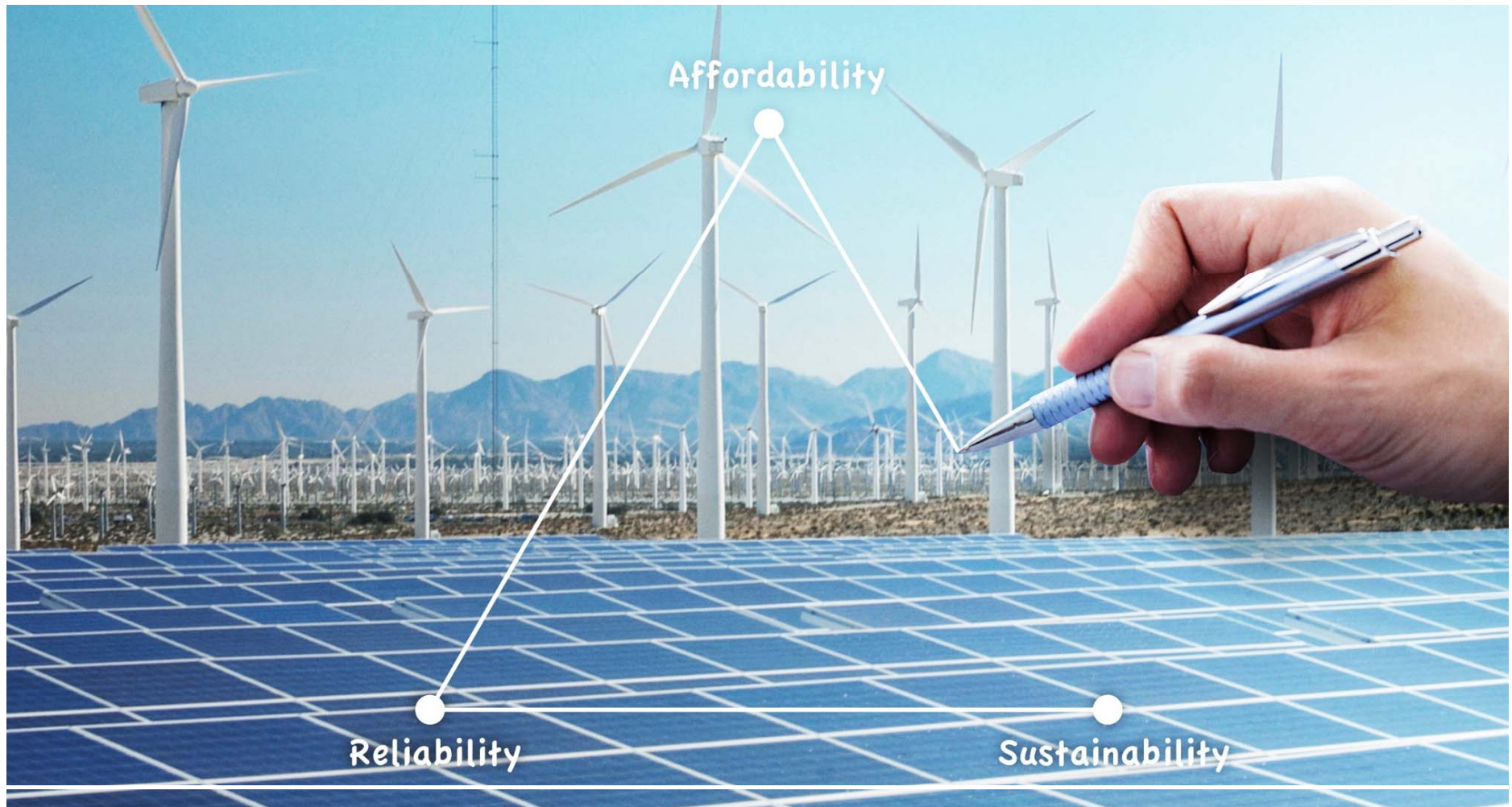
Climate change and extreme weather

Growing share of renewables

Security and ageing assets



## Assisting companies in solving the energy trilemma



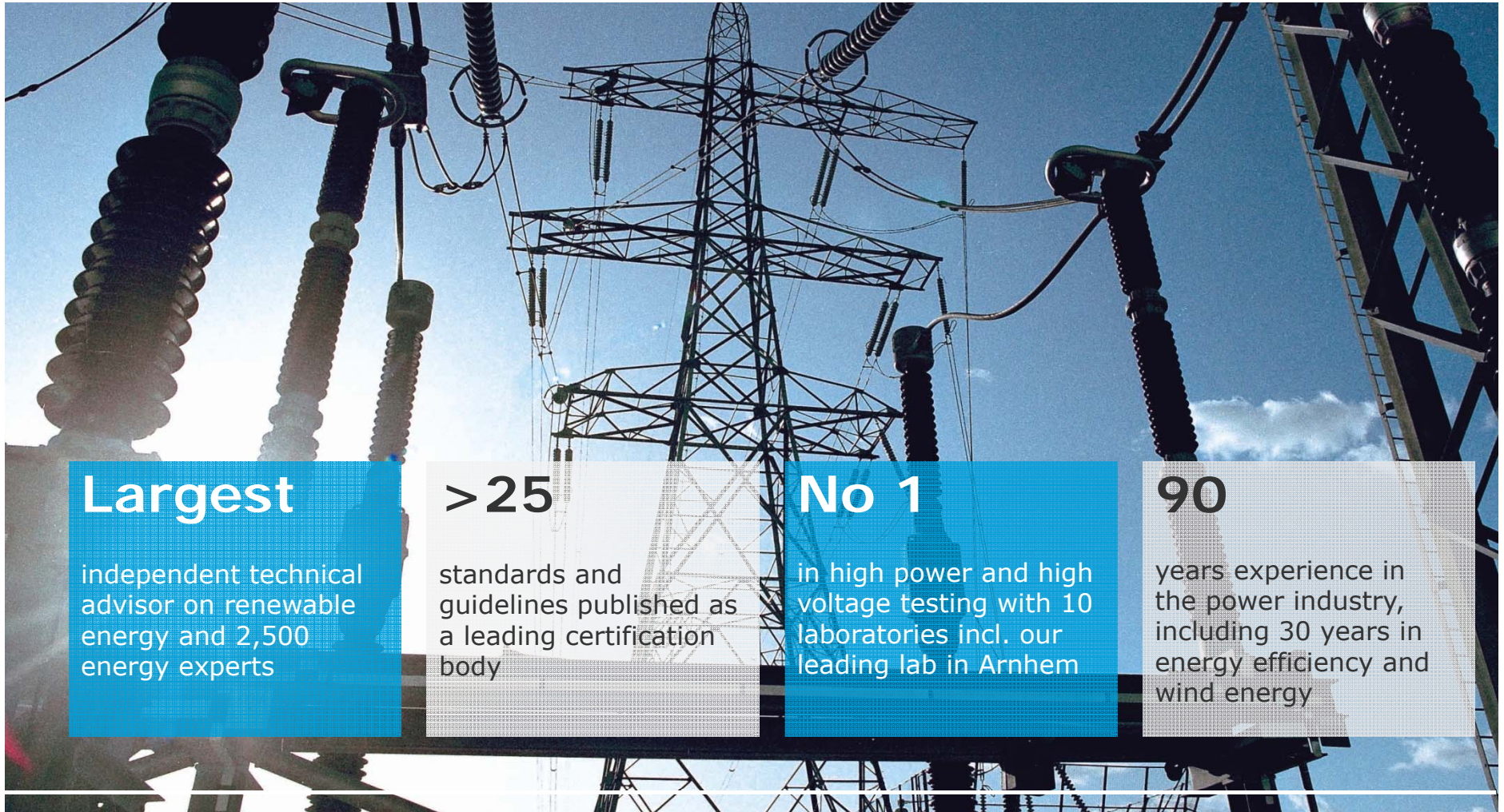
## Global service portfolio



- Power testing, inspections and certification
- Renewables advisory services
- Renewables certification
- Electricity transmission and distribution
- Smart grids and smart cities
- Energy market and policy design
- Energy management and operations services
- Energy efficiency services
- Software



## An energy technology powerhouse



**Largest**  
independent technical advisor on renewable energy and 2,500 energy experts

**> 25**  
standards and guidelines published as a leading certification body

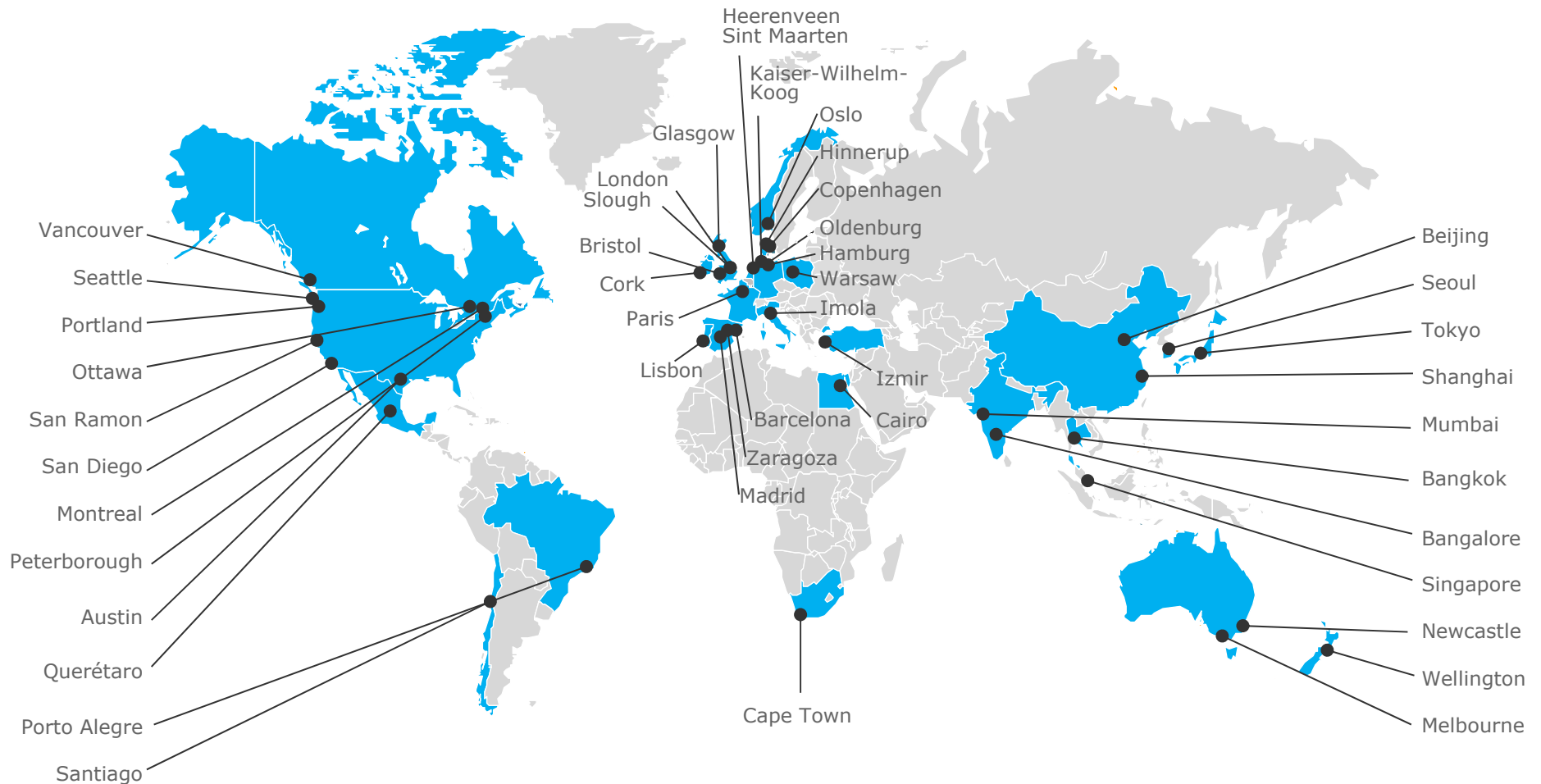
**No 1**  
in high power and high voltage testing with 10 laboratories incl. our leading lab in Arnhem

**90**  
years experience in the power industry, including 30 years in energy efficiency and wind energy



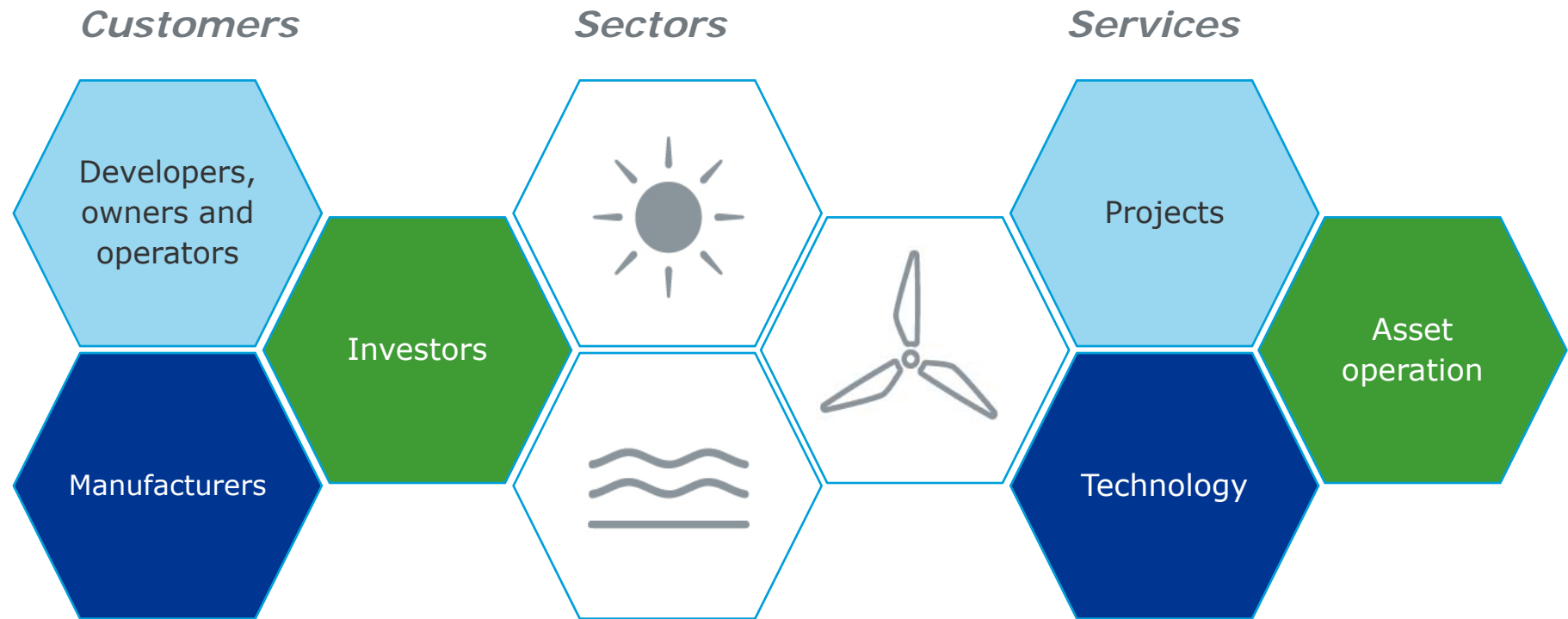
## Geographical Reach in Renewables

More than 1000 renewables staff, in 50 locations, across 27 countries



## Our Work in Renewables

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We work with our customers...

...in the solar, onshore wind and offshore renewables sectors...

..to support their projects, technology and asset operations.

## 2. Overview of Wind Farm Development and Engineering Services



# Services and Core Expertise during Development and Construction



Services

- Site prospecting feasibility studies
- Mesoscale and virtual mast data
- Feasibility assessment (environmental, social, technical, economic, financial)
- Measurement campaign design and installation (met towers and remote sensing)

- Wind farm layout optimization based on cost of energy
- Wind farm impact studies: sound, shadow flicker, ice throw, visual simulation, expert testimony
- Interconnection studies
- Design support
- Conceptual engineering layout, design and bid specifications
- RFP generation, execution, and evaluation
- Capex and Opex budgeting
- Technical due diligence

- Construction monitoring
- Commissioning monitoring
- Construction quality control inspections and document review
- Power performance testing
- Pre- and post-construction sound monitoring and propagation modeling

Expertise

- Energy assessments
- GIS
- Environmental permitting
- Economic and financial
- Transmission and distribution (T&D) system planning

- Energy yield assessments
- Turbine engineering
- Civil engineering
- Electrical engineering
- Transmission and distribution (T&D) system planning
- Curtailment and congestion studies
- Environmental permitting
- Contracting (procurement, construction, O&M, warranty, management contracts, etc.)
- Project management and execution

- Turbine engineering
- Civil engineering
- Electrical engineering
- Project management
- Measurements
- Inspection and audit

### 3. Value Proposition

## 1. Highest Level of Expertise

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- Efficiently provide technical solutions in the development process based on back-end experience in the design, construction, operations and project financing of over 33 GW of projects in North America
- Opinions on all commercially available turbines
- Capital cost database for 60% of the projects in North American
- Database of more than 15 GW operational projects in North America to benchmark performance and operating budgets
- Transmission system planning expertise with 30 engineers
- Driving the definition of industry standards:
  - IEC 61400
  - ASCE-AWEA – Recommended practice for wind turbine support structures
  - CSA Turbine Standards, cold weather and site suitability
- Focus on innovation and R&D: 5% of annual revenue reinvested into research and development every year

## 2. Driving Down the Cost of Energy

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- Enable our customers to maximise the potential of their projects and to drive cost competitiveness through intelligent application of technical solutions.
- Holistically designed wind farm layouts design based on cost of energy through integrated expertise.
- One stop shop for project development, conceptual design, contracting, energy assessment, and construction monitoring, allowing for better decisions to be made faster.
- Industry-leading expertise in supporting project financing ensures sharp focus on early technical risk identification and mitigation to ensure project bankability.



### 3. Commercial Focus

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- Solution-oriented with actionable recommendations
- Efficiently delivering the appropriate amount of detail to enable developers to intelligently compare project designs/costs, knowledgeably conduct contractual negotiations, identify critical issues/paths, etc.
- Fluently working across commercial and technical areas.
- Single point of contact with a project team tailored to customer needs and internal expertise

## 4. Detailed Service Summary

## Opinions on Turbine Technology

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- Immediate opinions available on all major turbine models, have visited many manufacturing facilities, inspected most turbine models
- Substantial experience with most major turbine platforms, not only through EOW inspections, but power performance, acoustic noise and power quality testing
- DNV GL has conducted the vast majority of power performance, mechanical loads, acoustic emissions, and other technical wind turbine measurements in North America.
- Services include:
  - Root cause analyses
  - Inspections
  - Concept design
  - Control systems
  - Loads and finite element analyses

# Comprehensive Turbine Technology Selection

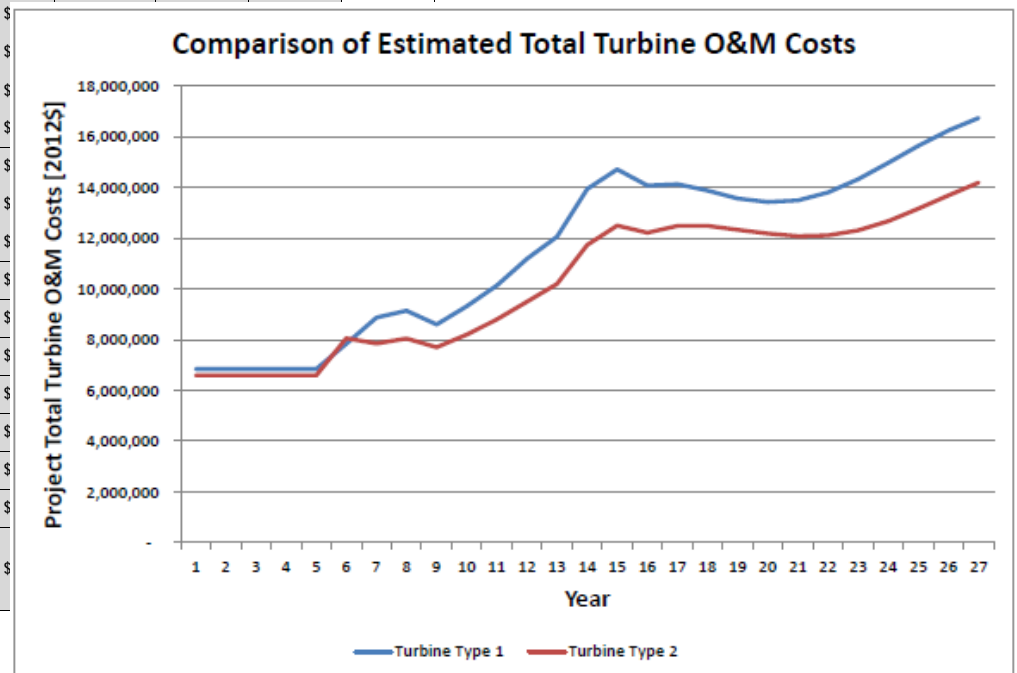
Manufacturer		Notes	Turbine 1	Turbine 2							
			Value	Value							
1 Offer Summary											
1.1	Turbine Model Proposed	Manufacturer		Score Weight	Scoring Method	Turbine 1		Turbine 2			
1.2	Hub Height (m)					Info	Score	Weighted Score	Info	Score	Weighted Score
1.3	Number of Turbines										
1.4	Project Capacity (MW)										
1.5	Project NCF (%)										
1.6	Project P50 Production (GWh/annum)										
2 Pricing, Cost of Energy											
2.1	Price Per Turbine (delivered/commissioned) (2014\$)										
2.2	Erection price per turbine (2012\$)										
2.3	Project Turbine Capital Cost (2014\$)										
2.4	Normalized Turbine Cost (2014\$/kW)										
2.5	Turbine O&M Option A Cost (2012\$)										
2.6	Turbine O&M Option B Cost (2012\$)										
2.7	Turbine O&M Option C Cost (2012\$)										
2.8	Estimated Average Annual Turbine O&M Cost (27-year, 2012\$/WTG)										
2.9	Total Estimated Turbine O&M Cost (27 year, 2012\$)										
2.10	GL GH Turbine Availability Projection										
2.11	GL GH Turbine Design Status (Proven/Qualified/Unproven)										
2.12	Turbine Evolution										
2.13	Defect Warranty										
2.14	O&M Proposal - Term offered (incl. extensions)										
3.1	O&M Proposal - Scope (scheduled/unscheduled/etc.)										
3.2	Total Estimated BOP O&M Cost (27 year, 2012\$, includes backfeed payment)										
3.3	Project BOP Cost (2012\$)										
3.4	Normalized Project BOP Cost (2012\$/kW)										
3.5	Foundations Capital Cost										
3.6	Roads, Other civil infrastructure Capital Cost										
3.7	Electrical BoP - Collection System Capital Cost										
3.8	Electrical BoP - Substation/T-line/Interconnection Capital Cost										
3 Technology and Suitability Risk Evaluation											
3.1	Certification Status										
3.2	Site Suitability										
3.3	Power Performance										
3.4	Noise										
3.5	Performance Track Record and Known Issues - Blade										
3.6	Performance Track Record and Known Issues - Gearbox										
3.7	Performance Track Record and Known Issues - Generator										
3.8	Performance Track Record and Known Issues - Converter										
3.9	Performance Track Record and Known Issues - SCADA and CMS										
3.10	Performance Track Record and Known Issues - Balance of Turbine										
3.11	Long Term Spare Parts Availability										
3.12	Temperature Range										
3.13	Lightning - LPS Class and experience										
4 Applicable Commercial Terms											
4.1	Draft Contracts Provided with RFP submittal? (yes/no)										
4.2	Limit of Liability										
4.3	Defect Warranty - Notable Exclusions										
4.4	Serial Defect - Warranty										
4.5	Serial Defect - Notable Exclusions										
4.6	Warranty extension on repair parts/labor										
4.7	Availability Warranty										
4.8	Availability Warranty - Percentage Warranted										
4.9	Availability Warranty - Exclusions										
4.10	Availability Warranty - True Up Percentage Warranted										
4.11	Availability Warranty - Availability LDs										
4.12	Power Curve Warranty										
4.13	Power Curve Warranty - Percentage Warranted with Uncertainty										
4.14	Power Curve Warranty - LDs										
4.15	Noise Level Warranty										
4.16	Noise Level Warranty - dB(A)										
4.17	Noise Level Warranty - LDs										
4.18	Force Majeure Definition										
4.19	Force Majeure Exclusions										
4.20	Payment Schedule (incl. holdback amounts)										
4.21	Delivery liquidated damages / delivery schedule										
4.22	Commissioning liquidated damages										



## O&M Budgeting over Project Life

- Smarter data use and probabilistic modeling to deliver optimized lifecycle strategies and better decision making for owners and operators.
- O&M knowledge is validated with over 15 GW of operational wind farm data.

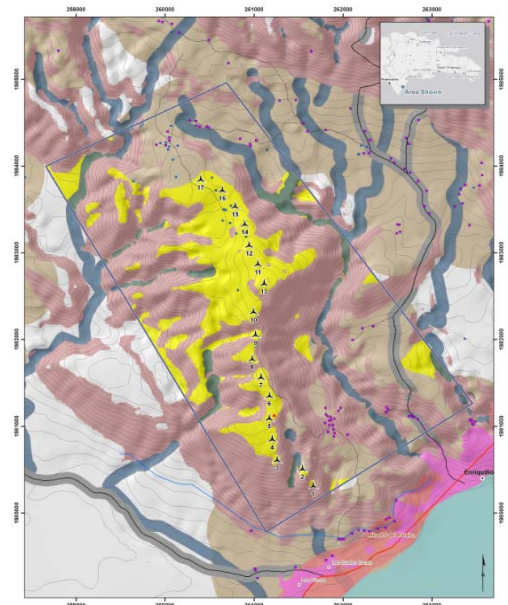
Event Specific Information		Labor Cost [\$]		Part Cost [\$]		Crane Cost [\$]		Event Cost [\$]	
	Event Type	Low	High	Low	High	Low	High	Low	High
Gearbox	Replace	\$	\$	\$	\$				
	Refurbish	\$	\$	\$	\$				
	Up-tower repair	\$	\$	\$	\$				
Generator	Refurbish	\$	\$	\$	\$				
	Bearing replacement	\$	\$	\$	\$				
Blades	Replace	\$	\$	\$	\$				
	Structural repair	\$	\$	\$	\$				
	Non-structural repair	\$	\$	\$	\$				
Main Bearing	Replace	\$	\$	\$	\$				
Transformer	Replace	\$	\$	\$	\$				
Pitch	Major repair	\$	\$	\$	\$				
Yaw	Major repair	\$	\$	\$	\$				
Hydraulics	Replace/repair	\$	\$	\$	\$				
Power Converter	Replace/repair	\$	\$	\$	\$				
Routine Wear and Tear / Minor Repairs per turbine per year		\$	\$	\$	\$				



# Wind Farm Layout Optimization Process

*Wind farm layouts optimized for cost of energy balancing the simultaneous needs of optimizing energy and minimizing wind farm costs.*

- Optimized for energy based on:
  - wind resource,
  - site suitability,
  - available land with environmental, social, and technical setbacks
  - constructability,
  - capital and operational cost implications
- Layout designs from feasibility to micro-siting
- Ensured compliance with applicable regulations (sound, visual, shadow flicker etc.)



## Owner's Engineering

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DNV GL has provided owner's engineering services on more than 150 wind farms in North America. Services include:

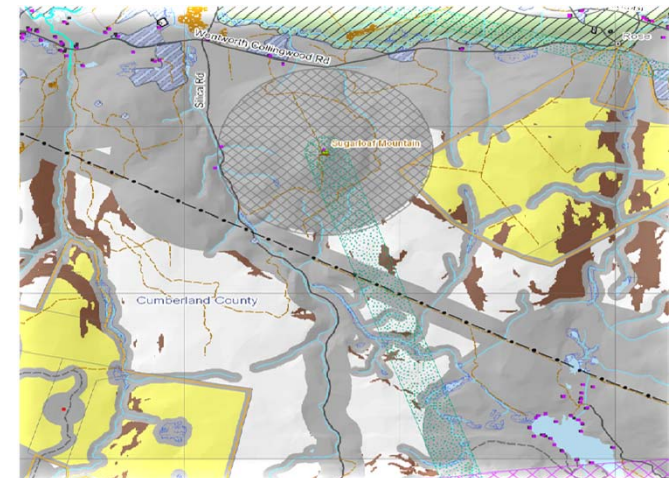
- Review and negotiating on key supply contracts
- Conceptual design and cost estimation
- Budget input reviews (capex and opex)
- Drafting RFPs for turbine supply and balance of plant
- Bid evaluation
- Construction project management and quality assurance
- Commissioning and reliability testing
- Substantial completion sign off



## Site Prospecting

DNV GL selects optimal sites for its clients using:

- Virtual met masts or mesoscale wind speed maps to identify wind resource
- Constraints analysis (exclusion zones) and setbacks applied on key features of technical, social, environmental variables to determine size of a potential project
- Evaluation of space on transmission grids to determine interconnection capacity and costs
- Market studies to determine market prices and opportunities
- Environmental permitting fatal flaw considerations
- Civil engineering fatal flaw analyses



# Wind Farm Noise Modelling and Acoustic Measurements

*Authority in acoustics. Sound modelling to ensure best-practice layout optimization and regulatory compliance.*

- Pre-construction sound assessments and modelling
- Pre- and post-construction on-site measurements and validations
- Accredited sound emissions testing for wind turbines
- Stakeholder engagement and outreach, including demonstration sound station at open houses
- Expert testimony and litigation support

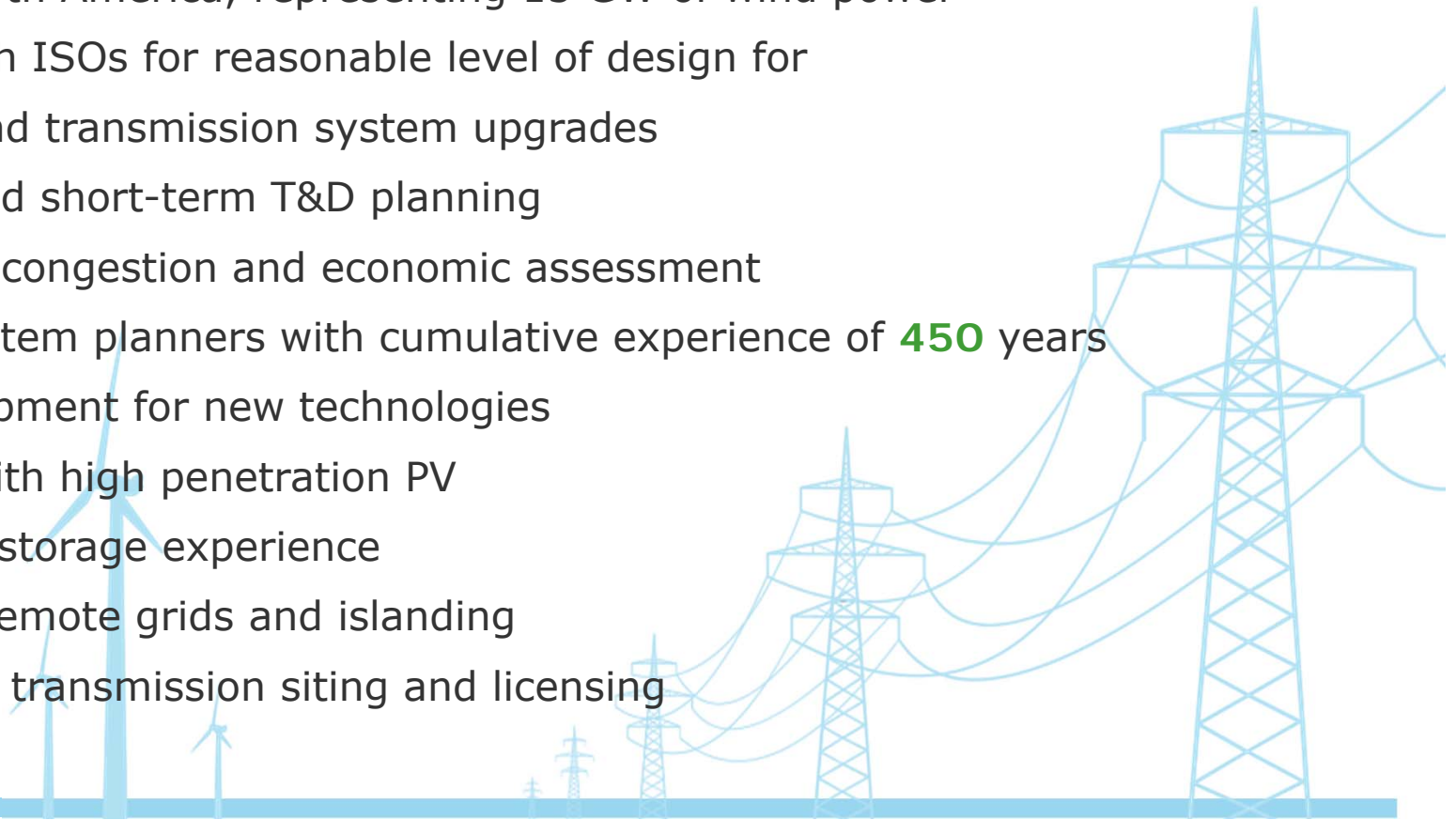


## Transmission System Planning

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*State of the art power flow modeling evaluating business case for power generation and transmission.*

- Performed 250 generation interconnection and transmission system assessment studies in North America, representing 15 GW of wind power
- Negotiate with ISOs for reasonable level of design for substation and transmission system upgrades
- Long-term and short-term T&D planning
- Transmission congestion and economic assessment
- **35** power system planners with cumulative experience of **450** years
- Model development for new technologies
- Experience with high penetration PV
- Deep energy storage experience
- Expertise in remote grids and islanding
- Experience in transmission siting and licensing





## Energy Assessments

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- Conducted wind assessments of over 170,000 MW globally
  - Over 85,000 MW assessed in the US and Canada
  - Of these 85,000 MW, over 34,000 are now operating in the US and Canada
- Performed operational energy assessments on over 30,000 MW globally
  - Over 12,000 MW assessed in the US and Canada
  - Increased resolution on individual project performance characteristics
  - Improved understanding of differences between pre-construction wind assessments and operational performance
- Greatest energy production validation database including 200<sup>A2</sup> wind farms wind farms and 500<sup>A3</sup> wind farm years of production in North America
- Current methods exhibit no bias in comparison to actual production, but of course there is more work to be done

## Slide 32

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**A2**      check statistics with Melissa  
Author, 14/06/2014

**A3**      check statistics with Melissa  
Author, 14/06/2014

## Resource Measurement Services

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*Turnkey mast installation ensuring a robust, reliable, and bankable measurement campaign.*

- Installed more than 1,300 tubular met masts and 100 lattice met masts around the world
- Range of services, from turnkey to inspection and decommissioning.
- Instrumentation recommended for lowest WRA uncertainty & highest data recovery
- Experienced in sites with challenging access (helicopter) and harsh weather (icing)
- Industry-leading Online Data Management system ensures max data collection
- Mast installation for power performance
- Solar installation services available





## Ground-Based Remote Sensing – Lidar and Sodar

- Wind resource assessment, onshore & offshore
- Site suitability analysis
- Power performance analysis
- Turnkey solutions (procurement, siting, commissioning, operation)
- On-site testing, validation and monitoring
- On-line data archiving and reporting
- DNV GL owns a Z300 ZephIR Lidar that can be rented
- Power-pack for an autonomous operating in remote areas



## Power Performance Testing

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- DNV GL has conducted the vast majority of power performance, mechanical loads, acoustic emissions, and other technical wind turbine measurements in North America.
- DNV GL has conducted IEC-compliant power performance measurements on over **400** turbines from most major manufacturers across the globe.
- DNV GL has conducted multiple power performance tests using ground-based and nacelle-mounted lidar.
- DNV GL gives you flexibility—especially if a power performance test was not conducted when a wind project was originally built—and underperformance of turbines is an issue.

## Environmental and Permitting Services

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*With a team of biologists, engineers, land use planners, and project managers, DNV GL offers unparalleled ability deliver county, state, and federal permits including environmental impact assessments, conditional use permits, and other regulatory approvals.*

- Over the past 10 years, DNV GL has provided the following services:
  - 5+ GW of environmental assessments in North America
  - 7+ GW of due diligence review for financing or acquisition
  - 15+ GW of environmental studies of various types (such as sound monitoring/modelling, EMI studies, visual impact assessments, constraints analysis, etc.)
  - 150+ feasibility and critical issues analysis (Tier II)
- Team includes a robust GIS group capable of all spacial analysis, data management, and 3D imagery services



## Biological Assessments

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- Wildlife studies
  - Desktop reviews
  - Habitat assessment
  - Pre-construction avian and bat monitoring programs
  - Aerial nest surveys
  - Impact assessments
- Federal and state agency consultation/coordination
- Mitigation and monitoring plans
  - Avian Bat Protection Plans and Eagle Conservation Plans
  - Post-construction fatality monitoring
- Annual agency reporting





## Cultural and Historical Resource Assessments

- Archaeological studies
  - Desktop assessments
  - Review of past land occupation
  - Determine “archaeological potential” of Project area – likelihood of finding artifacts
  - On-site archaeological evaluations
- Heritage/Paleo studies
  - Review of historic records, state and national databases
  - On-site evaluations
  - Impact assessments
- Traditional land use studies
- Tribal or First Nations engagement/consultation



## Phase I Environmental Site Assessments

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*Qualified Environmental Professionals support Phase I ESA preparation and updates through the life projects.*

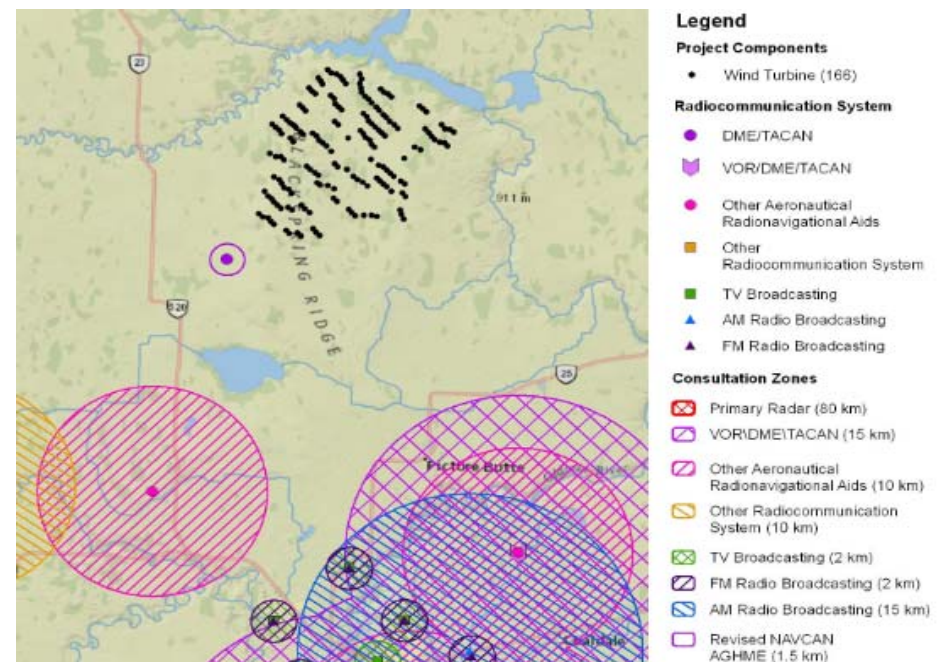
- Key document for limiting liability under CERCLA
- Multiple Phase I ESAs performed since recently adopted ASTM Standard changes
- Engineers and scientists able to perform all mapping, site visits, and reporting activities in most DNV GL offices in North America
- Through our turn key approach, Phase I ESA data can be considered to assist with facility siting and site visits can be combined with other field work to provide significant cost savings
- DNV GL has reviewed more Phase I ESAs for wind and solar facilities in the course of due diligence than any other environmental consultant

# Electromagnetic Interference & Radio-Communication Assessment

*Radio-communication and radar system inventory is compliant with the RABC/CanWEA and FAA guidelines<sup>1</sup> or any other applicable local guidelines.*

- Broadcast Transmitters (AM, FM, TV stations and MMDS)
- Aeronautical Stations and Radio Navigation Aids
- Maritime Stations and Radio Navigation Aids
- Land Mobile and Fixed Radio Systems
- Over-the-Air Reception Systems
- Weather Radar Systems
- Point-to-Point Systems
- Cellular Type Network
- Satellite Systems
- Radiolocation Systems
- DNV GL offers mitigation recommendations and complaints management programs.

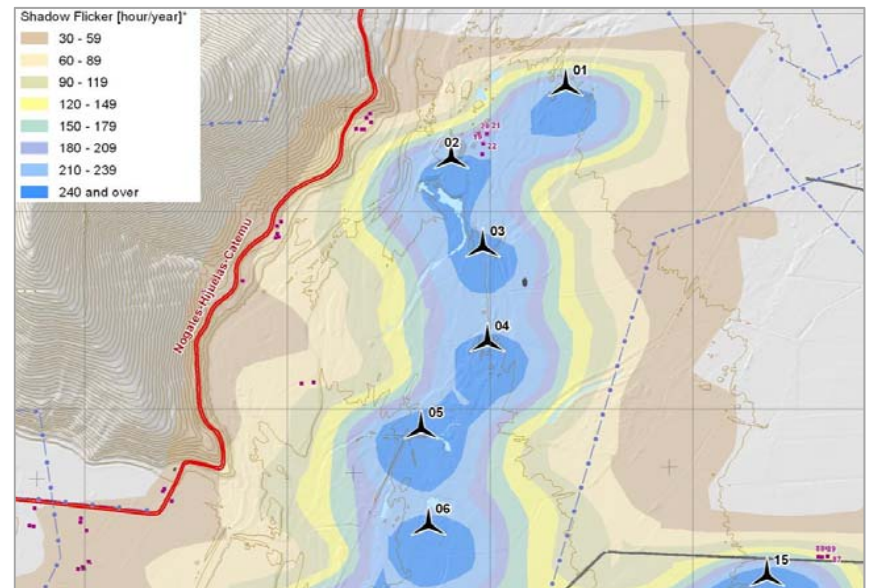
<sup>1</sup> Radio Advisory Board Canada (RABC),  
Canadian Wind Energy Association (CanWEA)  
Federal Aviation Administration (FAA)



## Shadow Flicker Assessment

*Shadow flicker studies to ensure best-practice layout optimization and facilitates regulatory compliance.*

- Modeling done with validated in-house WindFarmer software
- Astronomical case methodology for worst-case estimates
- Refined methodology for most likely shadow flicker estimates, incorporating wind rose, turbine operation, and weather conditions
- Visually appealing shadow flicker maps
- Rigorous and comprehensive reports
- Expert testimony

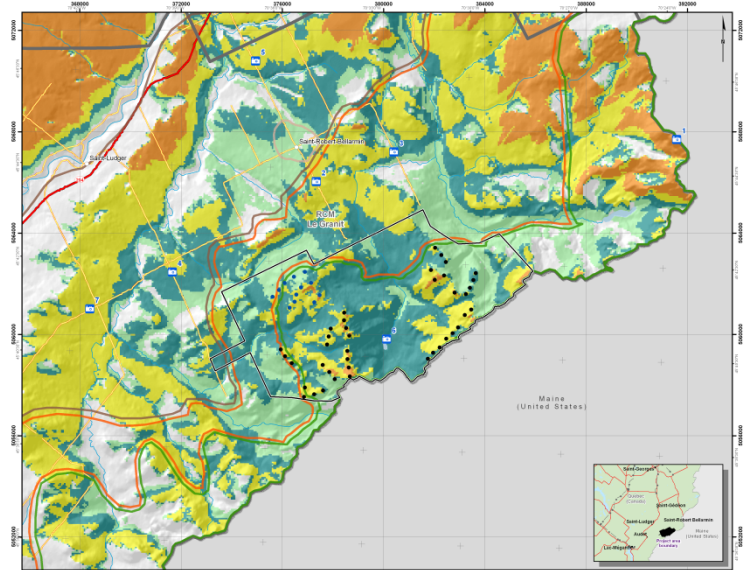




# Visual Impact Assessment

*Realistic and visually stunning photomontage simulations, using in-house software and skills, required for open houses and Visual Impact Assessments.*

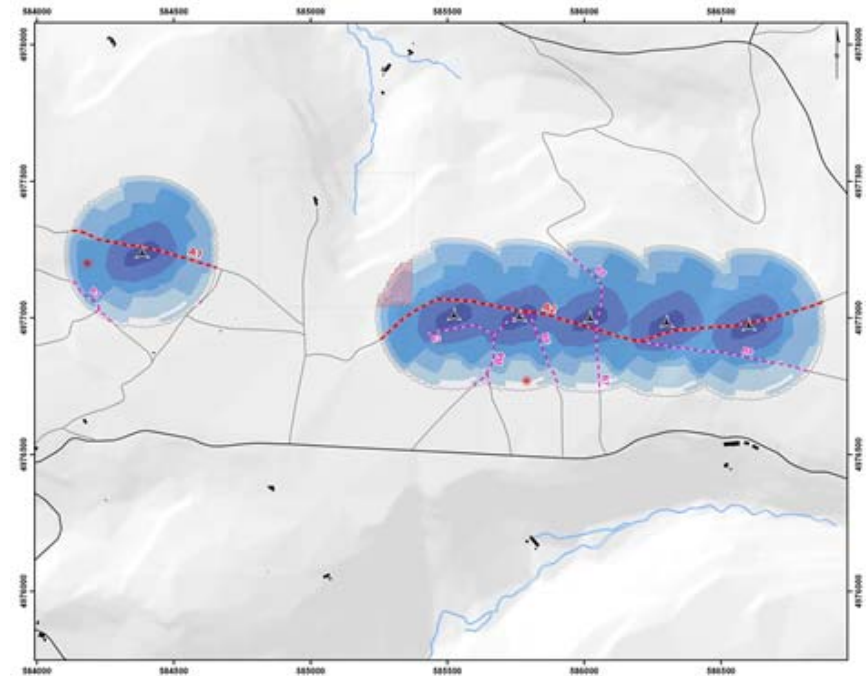
- Trained local staff to take photographs in key markets
- Realistic photomontage simulations from customized viewpoints
- Zone of Visual Influence studies
- Modeling of project infrastructure, including transmission lines and landscaping mitigation plans
- Experts for open house event



# Ice Throw Risk Assessment

*Detailed ice throw risk studies to assess the potential impact from ice drop and throw*

- Meteorological estimate of annual icing days on site
- Directional ice throw probability analysis
- Risk analysis of ice throw/drop impact on dwellings, roads and other infrastructure
- Expert testimony, if required



## Stakeholder and Community Engagement

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*With a wealth of technical and social experts, DNV GL can offer support for all aspects of stakeholder, agency, community, and tribal engagement.*

- Preparation and implementation of public, agency, and tribal consultation programs
- Identification of all local stakeholders
- Public meetings with local population and stakeholders
- Preparation of poster board or presentation material such as visual simulations, maps, information boards, turbine sound simulation rooms, etc.
- Stakeholder comments tracking
- Issues and complaints resolution
- Public hearings and expert testimony



## Construction and Operational Environmental Compliance

*Qualified professionals to monitor construction activities and facilitate environmental compliance through operations.*

- Construction phase environmental monitoring, including wetland, habitat, sensitive features, and archeological monitoring
- Operational phase acoustic audits and measurements
- Operational phase avian and bat fatality monitoring
- Spill Pollution Control and Countermeasure (SPCC) Plans
- SWPPP preparation and NPDES/Stormwater Monitoring





## 5. Managing Technical Risks

## How much energy can you expect to produce?

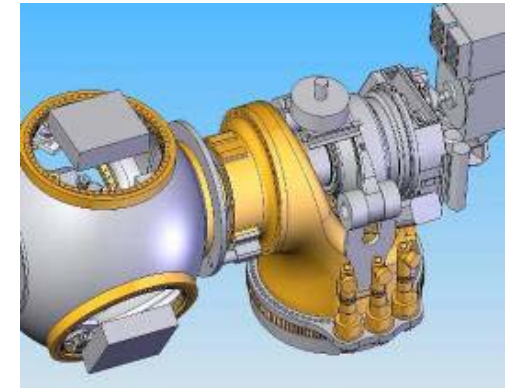
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GL Garrad Hassan has assessed the energy production of over 100,000 MW of wind projects, in dozens of countries, and continues to underpin developments for most of the major developers.

- Assessment of the long-term wind resource and energy output
- Validated modeling of turbine wake losses – for layout design and energy output calculation
- Detailed engineering analysis of other energy loss factors (availability, electrical, turbine performance, environmental, curtailments)
- Prediction of seasonal and time of day wind speeds and energy output
- Comprehensive analysis of energy output uncertainty
- Assessment of site meteorological conditions for wind turbine suitability evaluation

## How will the turbine technology perform?

- How well has it been operating?
- What long-term availability is achievable?
- What problems still need to be resolved?
- Is it a proven turbine?
  - Viable Company – The manufacturer is capable of performing all contractual and commercial obligations in North America;
  - Service & Infrastructure – The manufacturer can demonstrate the ability to support warranty, O&M, and supply chain obligations in North America;
  - Certified Design – The version of the turbine that will be supplied to North America carries a valid Design Statement of Compliance (SoC) to IEC 64100-1 standards issued by an accredited certification agency;
  - Track Record – There are at least 100 turbine-years of experience in the North American market, operating at  $\geq 95\%$  fleet turbine availability



## Is the turbine designed to withstand site conditions?

- Do the site conditions exceed the turbine design parameters? By how much?
- What will the impact be of high loading conditions on the turbines, component failure rates, project operation and O&M costs?
- Will the turbine manufacturer guarantee that its turbine can withstand the site conditions? How exposed is the project?

**Table 1 – Basic parameters for wind turbine classes<sup>1</sup>**

Wind turbine class	I	II	III	S
$V_{\text{ref}}$ (m/s)	50	42,5	37,5	Values specified by the designer
A $I_{\text{ref}}$ (-)	0,16			
B $I_{\text{ref}}$ (-)	0,14			
C $I_{\text{ref}}$ (-)	0,12			



## Is the capital budget reasonable? What about operating budget revenues and expenses?

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- Have all necessary and contracted EPC costs been accounted for in the capital budget?
- Is the balance of plant construction budget contingency sufficient?
- Do the O&M expenses account for appropriate component failures rates and component costs?
- Are sufficient funds available over the project life as component failure rates increase as the project ages?
- How does the O&M budget compare to industry average?



## Are the grid interconnection and power sales agreements beneficial to the Project?

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- Curtailment?
  - How much curtailment is expected? 10% of year? 20% of the year? More?
  - Any compensation for curtailment?
- Grid Interface
  - Has the turbine demonstrated LVRT compliance?
  - Can the turbine controls support ramp-up, ramp-down and curtailment requests?
- Is the design of the collection system, substation, transmission system appropriate for 20 years? Downtime for maintenance?
- Utility Reporting Requirements
  - Does the SCADA system support the reporting requirements of the Project Developer, NERC, Transmission Owner?



## Are the foundations designed appropriately?

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- Turbine loads analysis required for foundation design
- Soil and subsoil conditions (evaluation of geotech studies)
- What type of foundation (pile, pier, rock anchor, gravity)? Supported by soil type?
- Full design review with parallel calculations
- Construction site visits
- Quality monitoring



## Turbine Guarantees, Warranties, and O&M Service

- Quality of Operation & Maintenance Services

- Service arrangements
- O&M facilities
- Third party provider?
- Support structure
- 24/7 operation?



- Guarantees/Warranties

- Defects – 5 years?
- Serial defects?
- “Effective” availability
- Sound level
- Power curve





## BoP Contracts

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- Alignment of contracted work
  - Equipment delivery and offloading
  - Turbine erection
  - Turbine mechanical completion and commissioning
  - SCADA installation
- Quality Control / Quality Assurance
  - Program
  - Documentation



## Site Appreciation

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- What are the transportation and construction logistics?
- Local infrastructure?
- Weather concerns? Thaw periods?
- Local labor force?
- Residents & sound levels?



**For more information, visit our  
website:**

[www.dnvgl.com](http://www.dnvgl.com)

[www.dnvgl.com/renewables](http://www.dnvgl.com/renewables)

# Thank you for your time.

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**[www.dnvgl.com](http://www.dnvgl.com)**

**SAFER, SMARTER, GREENER**